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Indian Standard

METHOD FOR SPECIFYING THE FUNCTIONAL PERFORMANCE OF STABILIZED POWER SUPPLY APPARATUS

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MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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November 1979

Indian Standard

METHOD FOR SPECIFYING THE FUNCTIONAL PERFORMANCE OF STABILIZED POWER SUPPLY APPARATUS

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Indian Standard

METHOD FOR SPECIFYING THE FUNCTIONAL PERFORMANCE OF STABILIZED POWER SUPPLY APPARATUS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 27 April 1979, after the draft finalized by the Electronic Measuring Equipment Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 This standard is intended to unify methods of expression of electrical properties of stabilized supply apparatus for measurement; to establish the terminology and definitions related to this apparatus and to specify methods for testing these types of apparatus in order to verify compliance with claimed or assured properties.

0.3 According to output quantity, supply apparatus may be of one or more of the following types:

a) DC supply with stabilized voltage;
b) AC supply with stabilized voltage;
c) DC supply with stabilized current; and
d) AC supply with stabilized current.

0.4 Throughout this standard, the term 'supply apparatus' or 'apparatus' only has been used to cover any apparatus and accessory according to the scope.

0.5 This standard is based on IEC Publication No. 443-1974 'Stabilized supply apparatus for measurement', issued by International Electrotechnical Commission (IEC).

0.6 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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*Rules for rounding off numerical values (*revised*).

1. SCOPE

1.1 This standard applies to the following apparatus:

a) Supply apparatus with stabilization, which is designed to supply calibrated values of voltage and/or current in connection with electrical measurement; and

b) Accessories used with this apparatus.

NOTE — A supply apparatus designed to supply calibrated values is characterized by having a specified accuracy under reference conditions, which is of the order of its stabilization. To apparatus falling within this scope the same performance concept is applied as to electronic measuring equipment in general.

The opposite case is a supply apparatus having an accuracy under reference conditions which is appreciably lower than its stabilization performance. It is not advisable to specify such apparatus in accordance with this standard.

1.2 Safety requirements are not dealt with in this standard.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following terms and definitions shall apply.

2.1 Supply Apparatus and Components

2.1.1 *Supply Apparatus* — An apparatus which takes electrical energy from a supply source, in general from the supply mains, and supplies electrical energy, in a modified form, to one or more loads.

2.1.1.1 *Stabilized supply apparatus* — A supply apparatus in which one or more of the output quantities are stabilized.

2.1.2 *Elements Used with Stabilization* — *See* Fig. 1, as an example.

2.1.2.1 *Output control device* — The device by means of which the specified values as indicated in **2.3.1.1** and **2.3.1.2** are set.

2.1.2.2 *Reference source* — The source of an electrical quantity, the value of which is referred to in closed loop stabilization.

2.1.2.3 *Comparator* — The device which compares the value of an output quantity with a value specified for reference purposes and produces a difference signal (error signal).

2.1.2.4 *Error amplifier* — The device which amplifies the difference signal (error signal) of the comparator.

2.1.2.5 *Final control element* — The last element which controls the output quantity to the specified value.

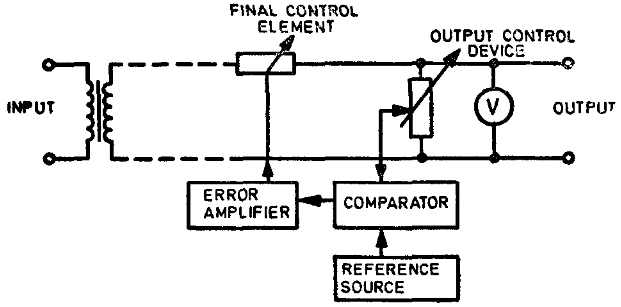


FIG. 1 FUNCTIONAL COMPONENT DIAGRAM OF A SUPPLY APPARATUS WITH STABILIZED VOLTAGE BY CLOSED LOOP STABILIZATION

2.1.3 *Accessory* — A device or an apparatus which is associated with the supply apparatus.

2.2 Basic Terms

2.2.1 *General*

2.2.1.1 *Performance characteristic* — One of the quantities assigned to an apparatus, in order to define by values, tolerances, ranges, etc, the performance of the apparatus.

NOTE — The term 'performance characteristic' does not include influence quantities.

2.2.1.2 *Rated value* — The value (or one of the values) of a quantity to be supplied or set, which the manufacturer has assigned to the apparatus.

NOTE 1 — For example, in the case of a supply apparatus with a calibrated output control, the rated output is the value indicated by the control setting. For a supply with a fixed output, the rated output is the output indicated on the nameplate.

NOTE 2 — The term *voltage* and *current* with ac quantities indicate rms values, unless otherwise specified.

2.2.1.3 *Rated range* (*setting range*) — The range of a quantity to be supplied or set, which the manufacturer has assigned to the apparatus.

NOTE — This is the range over which the value of the stabilized quantity may be adjusted.

2.2.1.4 *Effective range* (*control range*) — That part of the rated range where quantities can be supplied within the stated limits of error.

2.2.2 *Stabilization* — The reduction of the effect of changes of influence quantities and/or influencing characteristics on the output quantity by means inside the supply apparatus.

2.2.2.1 *Closed loop stabilization* — A mode of operation in which the value of an output quantity is compared with a reference value and such that the difference of these values controls directly or indirectly the output quantity to the specified value.

2.2.2.2 *Open loop stabilization* — A mode of operation in which the value of an output quantity is controlled by internal means to a specified value without evaluating the difference between the output and this specified value.

2.2.2.3 *Stabilized quantity* — The output quantity (or one of the output quantities) of a supply apparatus to which stabilization is applied.

NOTE 1 — In the general case, the output voltage and/or current will be stabilized.

NOTE 2 — Supply apparatus with ac output may be characterized according to the quantity to be stabilized, as defined in Note 4 below.

NOTE 3 — There will be at least one stabilized quantity, but more than one stabilized quantity may be assigned to a particular apparatus, for example for a voltage stabilized apparatus, the voltage is the stabilized quantity and the current is an influencing characteristic; for a current stabilized apparatus, the current is the stabilized quantity and the voltage is an influencing characteristic; and with a frequency (only) stabilized apparatus, the frequency is the stabilized quantity and both voltage and current are the influencing characteristics.

NOTE 4 — Concerning the output voltage or current, distinction is made between:

a) average value stabilization;
b) rms (effective) value stabilization; and
c) peak value stabilization.

These terms denote that the given value of the output voltage (current) is stabilized to specified values.

NOTE 5 — Frequency stabilization and waveform stabilization are under consideration.

2.2.2.4 *Remote sensing* — A means by which the supply apparatus monitors a stabilized output quantity directly at the load using extra 'sensing' leads.

NOTE — The resulting circuit action compensates for voltage drops in the load leads up to a specified limit.

2.3 Terms Concerning Influence Quantities

2.3.1 *Influence Quantity* — Any quantity, generally external to a supply apparatus, which may affect the performance of the apparatus.

NOTE — Where a change of a performance characteristic affects another performance characteristic, it is referred to as an *influencing characteristic*.

2.3.2 *Reference Conditions* — A set of values with tolerances or of restricted ranges of influence quantities and, if necessary, of influencing characteristics, specified for making comparison or calibration tests.

2.3.2.1 *Reference value* — The value of an influence quantity specified for the reference conditions.

2.3.2.2 *Reference range* — The range of an influence quantity specified for the reference conditions.

2.3.3 *Rated Range of Use* — The range of values for an influence quantity within which the requirements concerning operating error are satisfied.

2.3.4 *Rated Operating Conditions* - The whole of the effective ranges for performance characteristics and rated ranges of use for influence quantities, within which the performance of the apparatus is specified.

2.3.5 *Limit Conditions of Operation* — The whole of the ranges of values for influence quantities and performance characteristics (beyond the rated ranges of use and effective ranges respectively) within which an apparatus can function without resulting damage or degradation of performance, when it is afterwards operated under rated operating conditions.

NOTE — The limit conditions will, in general, include overload.

2.3.6 *Conditions of Storage and Transport* — The whole of the conditions of temperature, humidity, air pressure, vibration, shock, etc, within which the apparatus may be stored or transported in an inoperative condition, without resulting damage or degradation of performance when it is afterwards under rated operating conditions.

2.4 Terms Concerning Errors

2.4.1 Error

2.4.1.1 *Absolute error* — The error expressed algebraically in the unit of the supplied quantity.

For a supply apparatus, the error is the true value of the quantity supplied minus its rated, indicated or preset value.

NOTE — The true value of a quantity is the value that would be measured by a measuring process having no error.

In practice, since this true value cannot be determined by measurement, a conventionally true value, approaching the true value as closely as necessary (having regard to the error to be determined), is used in place of the true value. This value should be traced to standards agreed upon by the manufacturer and the user or to national standards. In both cases the uncertainty of the conventionally true value shall be stated.

2.4.1.2 *Relative error* — The ratio of the absolute error to a stated value.

2.4.1.3 *Percentage error* — The relative error expressed as a percentage, such as percent of full-scale (the maximum value of the effective range), percent of the indicated or preset value or of the rated value.

2.4.1.4 *Fiducial value* — A value to which reference is made in order to specify the percentage error, for example, the upper limit of the effective range or another clearly stated value.

2.4.2 *Limits of Error* — The maximum values of error assigned by the manufacturer to a supplied quantity of an apparatus operating under specified conditions.

2.4.3 *Intrinsic Error* — The error determined under rated reference conditions.

2.4.4 *Operating Error* — The error determined under rated operating conditions.

2.4.5 *Influence Error* — The error determined when one influence quantity assumes any value within its rated range of use (or an influencing characteristic assumes any value within its effective range), all others being at reference conditions.

NOTE — When over the whole rated range of use a substantially linear relationship exists between the influence error and the effect causing it, the relationship may be conveniently expressed in coefficient form.

2.4.6 *Stability Error* (*Drift*) — The error which occurs in the indicated or supplied value of an apparatus during a specified time, other conditions remaining constant.

NOTE — Stability error includes drift and PARD (*see* **2.8.1**).

2.4.7 *Variation* — The difference between the values of a performance characteristic when one influence quantity assumes successively two specified values within its rated range of use, the other influence quantities being at reference conditions.

2.4.8 *Influence Coefficient* — The change in value of an output quantity per unit of one influence quantity with all other influence quantities maintained constant at reference conditions.

NOTE — The influence coefficient should always be given as the maximum slope of the characteristic (*see* Fig. 2).

2.5 Waveform Distortion — Definitions rated to waveform distortion are under consideration. Suitable tests are described in **8.4.**

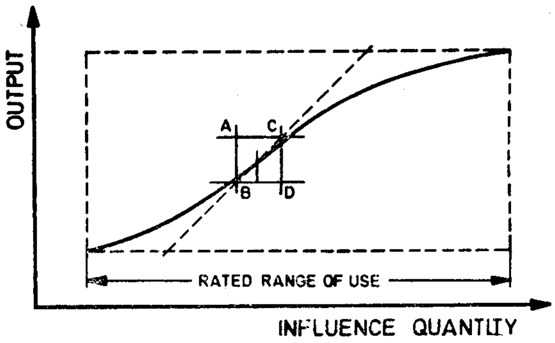


FIG. 2 DETERMINATION OF THE INFLUENCE COEFFICIENT ACCORDING TO THE MAXIMUM SLOPE. THE INFLUENCE COEFFICIENT IS EQUAL TO *AB* DIVIDED BY *AC*

2.6 Terms Concerning Temperature Performance

2.6.1 *Ambient Temperature* — The temperature of the medium in which the supply apparatus is immersed, usually the temperature of the air surrounding the apparatus.

NOTE 1 — The manufacturer will normally specify a permissible ambient temperature, which must not be exceeded during operation of the supply apparatus.

NOTE 2 — For stabilized power supplies incorporating their own forced-cooling units, the ambient temperature is the temperature measured at the cooling intake.

2.6.2 *Thermal Equilibrium* — A state under which the internal temperature of a stabilized supply apparatus does not change significantly.

2.6.3 *Settling Time* — The time interval between a change of an influence quantity or output setting and the point where changes of an output quantity are due only to drift or PARD (*see* **2.8.1**).

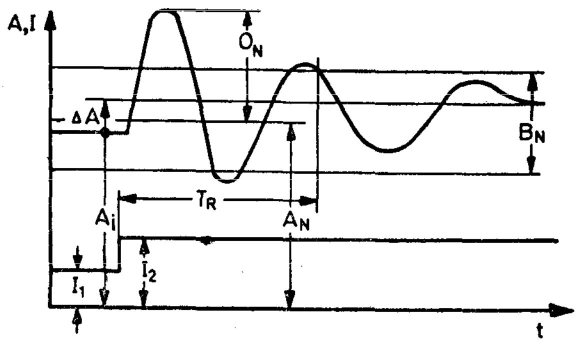
2.6.4 *Warm-Up Time* — The time interval after switching on the supply apparatus under specified conditions necessary for it to comply with all performance requirements.

2.7 Terms Concerning Transient Performance (*see* Fig. 3)

2.7.1 *Overshoot Amplitude* — The difference between the peak value of a transient excursion of an output quantity and its rated or final value.

NOTE — This concept is used in this standard only if the excursion is outside the limits of operating error.

2.7.2 *Recovery Time* — The time interval between the occurrence of a step change and the moment when the value of the output quantity enters and remains within the limits of operating error.



A = output amplitude
I = influence quantity
t = time
A_i = initial value of output quantity, existing prior to step change
ΔA = steady-state variation
T_R = recovery time
A_N = rated output value
B_N = operating error band, centered about A_N
O_N = overshoot amplitude with respect to rated value A_N
I_1, I_2 = influence quantity or influencing characteristic before and after step change respectively, which affects the output value

Fig. 3 Step Change Causing Output Transient (Operating Error Band with Respect to Rated Value)

2.8 Terms Concerning Periodic and Random Deviations

2.8.1 *PARD* (*Periodic and Random Deviations*) — The periodic and random deviations of an output quantity from its average value, over a specified bandwidth, with all influence quantities and influencing characteristics maintained constant.

Note — PARD may be stated in rms or peak-to-peak value or both for a specified bandwidth.

2.8.1.1 *Ripple* — The periodic portion of PARD, usually harmonically related to the input mains frequency or internally generated switching frequency or both.

2.8.1.2 *Noise* — The random portion of PARD.

NOTE — For noise not primarily of thermal origin (switching noise, quantizing, etc), it is desirable in order to describe the phenomenon to state the characteristics of the distribution law.

2.8.2 *Drift* — The (unwanted) generally slow and continuous change of a supplied quantity during a specified time, other conditions remaining constant.

NOTE — Drift includes both periodic and random deviations over the bandwidth from zero frequency (dc) to a specified upper frequency limit. This specified upper frequency limit shall coincide with the lower frequency limit for PARD so that all deviations under constant operating conditions are covered by one or the other specification.

2.9 Terms Concerning Impedances (of Circuits and Insulation)

2.9.1 *Output Impedance* — The complex ratio of a sinusoidal voltage and sinusoidal current at the output terminals, the one being caused by the other and being of external origin.

NOTE — It is a function of their frequency.

2.9.2 *Output Resistance* — The ratio of an incremental change of dc output voltage to an incremental change in dc output current, the one being caused by the other and being of external origin.

2.9.3 *Capacitance to Frame* — The capacitance measured between a specified terminal and a common point such as frame, guard or ground.

2.9.4 *Transfer Capacitance* — The capacitance measured between specified input terminals and output terminals.

NOTE — Sometimes referred to as ' leakage capacitance'.

2.9.5 *Output Capacitance* — In general, the capacitance measured between the output terminals. In particular, when the supply circuit employs a capacitor across the output terminals, the rated value of that capacitor.

2.9.6 *Maximum Floating Voltage* — For a floating output or input (control input), the maximum voltage that may be permanently maintained between specified terminals and frame.

2.9.7 *Insulation Resistance* — The resistance measured between any pair of specified points insulated from one another.

2.10 Terms Concerning Controlled Operation

2.10.1 *Control Behaviour* — The behaviour related to output changes resulting from intentional control by a human operator or by an electrical signal or a mechanical input.

2.10.1.1 *Discontinuous control resolution* — In the case of discontinuous control (for example by means of switches, wire-wound adjustable resistors), the maximum increment in the value of a stabilized output quantity arising from the smallest reproducible control element step.

2.10.1.2 *Incremental control coefficient* — The ratio of an incremental change in a stabilized output quantity to the incremental change in the control knob position causing it.

2.10.2 *Control Overshoot* — An overshoot resulting from a step change in output control setting.

2.10.3 *Remote Control* — The setting of the supply apparatus output by means of an external control quantity.

NOTE — In general, particular modes of remote control will be termed according to the applied signal or signal parameter, for example:

a) resistance control,
b) voltage control,
c) current control, and
d) digital control.

2.10.3.1 *Remote control coefficient* — The ratio of the control quantity value to the intended value of the output quantity.

NOTE — The control coefficient may vary over a range of control quantity values.

2.10.3.2 *Remote control deviation* — The difference between the actual value of the output quantity and the control quantity divided by the remote control coefficient.

NOTE — The control deviation includes non-linearity, slope error and offset effects.

2.10.3.3 *Control rate* — The maximum rate at which the stabilized output quantity can be varied as a result of control quantity changes without exceeding the limits of operating error.

2.11 Terms Concerning Load Characteristic

2.11.1 *Load Characteristic* — The functional relationship between the value of the output voltage and the value of the output current for a specified kind of current.

2.11.2 *Constant Voltage/Constant Current Crossover* — The behaviour of a supply apparatus that automatically converts the mode of operation from voltage stabilization to current stabilization when the output current reaches a preset value and *vice versa*.

2.11.3 *Crossover Area* — The range of values of the output quantities within which a change of mode of operation occurs.

NOTE 1 — Within this area, the output quantities are not well defined.

NOTE 2 — Unless otherwise specified, the crossover area is given by the overlap of the areas within the limits of operating error.

2.11.4 *Current Limiting* — The action of limiting the output current of a constant voltage supply to some predetermined maximum value (fixed or adjustable) and automatically restoring the output voltage to its normal value when the overload or short circuit is removed.

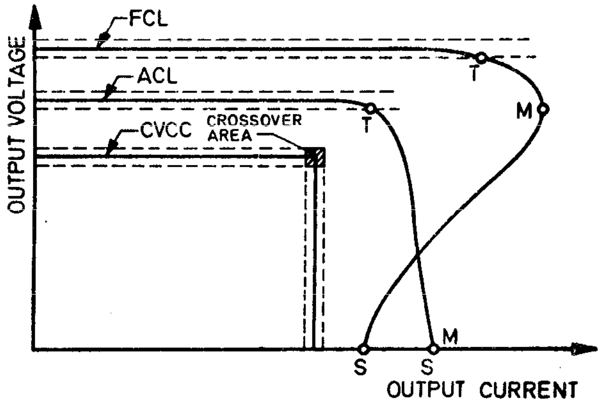
There are three types of current limiting (*see* Fig. 4):

a) by constant voltage/constant current crossover;

b) by decreasing output voltage as current increases (otherwise known as automatic current limiting); and

c) by decreasing both voltage and current as the load resistance decreases (otherwise known as 'foldback' or 'cutback current limiting').

NOTE — ' Current limiting ' is for use with voltage stabilized supply apparatus. For current stabilized supplies, the equivalent term is ' voltage limiting ' and the following terms and definitions apply in the opposite sense.



CVCC = constant voltage/constant current
ACL = automatic current limiting
FCL = foldback current limiting
T = current limit threshold
M = maximum limiting current
S = short-circuit current

The dotted lines refer to the limits of operating error.

FIG. 4 TYPES OF CURRENT LIMITING

2.11.4.1 *Current limiting threshold* — The value of the output current at which the limit of operating error for the output voltage is exceeded as the load resistance decreases.

2.11.4.2 *Maximum value of limited current* — Maximum value to which the current is limited and which may be obtained with a resistive load under steady-state conditions.

NOTE — This value may not necessarily be obtained continuously.

2.11.4.3 *Short-circuit values of limited current* — The steady-state current delivered by a constant voltage supply apparatus when its output terminals are short-circuited.

2.12 Terms Concerning Combined Operation of Several Supply Apparatus — In order to extend the output capabilities of a single supply apparatus, several supplies may be connected for a combined mode of operation. Frequently, terminals other than the output terminals may be interconnected, for example to provide a mode of operation where one supply (the master) may serve to control the others (the slaves).

2.12.1 *Slave Operation* — A method of operation when several stabilized supplies are interconnected and achieve coordinated control of the assembly by means of controlling the master supply alone, such combinations being characterized by essentially proportional outputs from all units.

2.12.2 *Parallel Operation* — The operation of several supplies with all positive output terminals connected together and all negative output terminals connected together, so that the total load current equals the sum of the output currents of each supply.

2.12.2.1 *Parallel operation with specified load sharing* — A method of operation when several stabilized supplies are connected in parallel, with the total load being shared between them in a prescribed ratio.

2.12.2.2 *Slave parallel operation* — A parallel connection of one master supply with one or more slaves with output current(s) always equal or proportional to the output current of the master unit.

2.12.3 *Series Operation* — A method of operation when several stabilized supplies operate with the positive output terminal of one connected to the negative output terminal of another, so that the output voltages of the supplies are additive.

2.12.3.1 *Series operation with specified load sharing* — A series connection of several supplies, with the total voltage being shared between them in a prescribed ratio.

2.12.3.2 *Slave series operation* — A series connection of one master supply with one or more slaves, with their output voltage(s) always equal or proportional to the output voltage of the master unit.

2.12.4 *Slave Tracking Operation* — A method of operation when several stabilized supplies are interconnected (involving one output terminal in common) with one or more slaves with output(s) always held equal or proportional to the output of the master unit.

NOTE — The slave may be of the same or opposite polarity as the master with respect to the common output terminal; in the latter case, the configuration is sometimes referred to as complementary tracking.

2.13 Terms Concerning Fault Protection

2.13.1 *Overcurrent Protection* — The protection of the supply apparatus and/or connected equipment against excessive output voltage due to failure of the supply apparatus including the open-circuit current.

NOTE — A stabilized supply apparatus may be protected against over-current of infinite or limited duration (absolute or limited overcurrent protection).

2.13.2 *Overvoltage Protection* — The protection of the supply apparatus and/or connected equipment against excessive output voltage due to failure of the supply apparatus including the open-circuit voltage.

2.13.3 *Undervoltage Protection* — The protection of the supply apparatus and/or connected equipment against excessively low output voltage due to failure of the supply apparatus.

NOTE — It may be effected by disconnecting the load.

2.13.4 *Reverse Voltage Protection* — The protection of the supply apparatus against reverse voltages applied at the output terminals.

2.13.5 *Reverse Current Protection* — The protection of supply apparatus against current fed back into the supply by the load.

2.13.6 *Overtemperature Protection* — The protection of the supply apparatus, or parts of it, against temperatures exceeding specified values.

2.13.7 *Reset* — The method by which the supply apparatus is brought back into operation after the malfunction has been corrected. Reset may be automatic or manual.

2.14 Terms Concerning The Input

2.14.1 *Power Factor* — The active power divided by the apparent power.

2.14.2 *Displacement Factor* — The active power of the fundamental wave divided by the apparent power of the fundamental wave.

NOTE — When the distortion is negligible, no difference is made between power factor and displacement factor, and the term cos θ is assigned to both.

2.14.3 *Efficiency* — The total output power divided by the active input power.

2.14.4 *System Efficiency* — The efficiency when the input power required to operate any auxiliary devices which are essential for operation.

2.14.5 *Inrush Current* — The maximum instantaneous value of the input current to the supply apparatus when switching on the supply.

2.14.6 *Distortion of the Input Current* — The distortion of the input current of a supply apparatus when connected to a source supplying an ac voltage of purely sinusoidal form.

2.14.7 *Ripple of the Input Current* — The alternating component present in the input current of a supply apparatus with dc input provided that it is fed by a dc source having negligible internal impedance.

2.14.8 *Turn-On (Turn-Off) Overshoot* — The overshoot resulting from the application (removal) of the input power or from the supply apparatus input switch being turned on (turned off).

2.14.9 *Turn-On (Turn-Off) Polarity Reversal* — The transient reversal of the output polarity following the application (removal) of the input power or the turn-on (turn-off) of the supply apparatus input switch.

3. GENERAL REQUIREMENTS CONCERNING STATEMENTS AND TESTS

3.1 The conditions and procedures described in this and the following clauses refer to statements and tests concerning:

a) the limits of operating error (*see* **4** and **5**),

b) the limits of intrinsic error (*see* **4** and **6**),

c) the limits of influence errors and coefficients (and possibly also variations) (*see* **7**),

d) other performance qualities (*see* **8** and **9**), and

e) the input requirements (*see* **10**).

3.2 As regards statements and verification, reference is made to IS : 9176-1979*.

3.2.1 *Statement of Limits of Error*

3.2.1.1 Limits of operating error (which apply under rated operating conditions) shall be stated.

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*Method for specifying functional performance of electronic measuring equipment.

3.2.1.2 Limits of intrinsic error (which apply under reference conditions) may be stated. In the absence of a statement they are considered to be equal to the limits of operating error.

3.2.1.3 Limits of influence error may be stated. It is particularly useful to state these limits when one influence quantity or influencing characteristic causes an important part of the operating error. It may also be of interest to state whether any environmental conditions do not contribute to the operating error.

NOTE — For stabilized supply apparatus, statements on variations may also be useful, under the conditions as above.

3.2.1.4 Regarding stability the manufacturer shall state:

a) either the maximum time interval within the limits of operating error are not exceeded, or

b) the limits of stability error together with the relevant time interval.

3.2.2 *Verification*

3.2.2.1 Testing under one or several combinations of values for influence quantities and influencing characteristic will, in most cases, adequately verify that an apparatus has the functional performance defined by the operating errors and conditions. One of these combinations gives the *reference conditions.*

3.2.2.2 Tests are preferably performed under reference conditions which closely approach the conditions under which calibration standards and calibration equipment are normally operated.

3.2.2.3 However, if it is considered necessary, additional tests may be performed at any combination of values for influence quantities and influencing characteristics within the rated operating conditions. Such tests are often expensive and would usually be performed only by agreement between the user and the manufacturer.

NOTE — It is understood that the manufacturer indicates in his catalogue sheet the combination of such values considers as essential.

3.3 Test Procedure

3.3.1 Test according to this standard are type tests unless otherwise indicated. Acceptance tests selected from these type tests should be agreed between the user and the manufacturer.

3.3.2 When carrying out type tests, each apparatus shall be subject to each of the tests laid down in this standard, as far as applicable and as agreed between the manufacturer and the user.

The sequence of tests is not indicated by the order of the clauses.

3.3.3 Unless otherwise specified, measurements for the verification of limits of error shall be carried out with instruments which do not appreciably (or only calculably) affect the values to be measured. In principle, the errors in measurements made with these instruments should be negligible in comparison with the errors to be determined.

3.3.4 When the error of the instrument is not negligible, the following rule shall apply:

> If an apparatus is claimed to have a limit of error of $\pm e$ percent for a given performance characteristic and the manufacturer uses for its checking an apparatus resulting in an error of measurement of $\pm n$ percent, the error being checked shall remain between the limits $\pm (e-n)$ percent. Likewise, if a customer checks the same apparatus resulting in an error of measurement of $\pm m$ percent, he is not entitled to reject the apparatus if its apparant error exceeds the limits of $\pm e$ remains between the limits $\pm (e + m)$.

3.4 General Conditions for Test Purposes — Tests are carried out under the conditions given in the sub-clauses below, and if so agreed, under that combination of conditions which results in maximum values of operating errors.

3.4.1 *Recommended Standard Values and Ranges of Influence Quantities*

3.4.1.1 The reference values or ranges, the rated ranges of use and the limit ranges of operation, storage and transport, for all influence quantities, shall be stated and shall be selected from only one of the Usage Groups I, II or III in **6** of IS : 9176 - 1979*. Any exceptions to the values given there, shall be explicitly and clearly stated by the manufacturer with an indication that they are exceptions.

3.4.1.2 The apparatus may correspond to one group of rated ranges of use for environmental conditions and to another group for mains supply conditions, but this shall be clearly stated by the manufacturer.

3.4.1.3 For the purpose of tests on stabilized supply apparatus, a selection of influence quantities and their reference values or ranges or both, is given in Table 1. Table 2 gives a selection of influence quantities and their rated ranges of use. Tables 1 and 2 apply to stabilized supply apparatus of Usage Group I, used under conditions which are normally found in laboratories and factories.

The values in these tables constitute for some influence quantities in addition or amendment to the values listed in the above recommendation.

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TABLE 1 REFERENCE CONDITIONS FOR TEST PURPOSES

(*Clause* 3.4.1.3)

SL No.	INFLUENCE QUANTITY OR CHARACTERISTIC	REFERENCE CONDITIONS	TOLERANCE ON REFERENCE VALUES
(1)	(2)	(3)	(4)
1	Ambient temperature	Reference temperature 27°C unless otherwise specified	For apparatus having an input consumption $\leqslant$ 50W: ± 1°C $>$ 50W: ± 2°C
2	Barometric pressure	101·3 kPa	To be specified
3	Relative humidity of the air	45% to 75%	—
4	Input voltage	Rated voltage or any voltage within the reference range	± 1% of the rms value
5	Input frequency	Rated frequency or any frequency within the reference range	± 1% if $\leqslant$ 200 Hz ± 2% if $>$ 200 Hz
6	Input waveform of alternating voltage	Sinusoidal (*see* Note 1)	Limit of envelope distortion $\beta \leqslant 0·05$ (*see* Notes 1 and 2)
7	Ripple of input direct voltage	Zero	$\frac{\text{Peak-to-peak ripple voltage}}{\text{Average input voltage}} \leqslant 5\%$
8	Input source impedance	So as to cause a voltage drop of 1·5% (*see* Note 3)	Drop between the limits 1....2%
9	Output voltage	*Max* rated voltage (*see* **2.3.2.3**)	± 1%
10	Output current	*Max* rated current (*see* **2.3.2.3**)	± 1%
11	Output frequency	Rated frequency or any frequency within the reference range	± 1% if $\leqslant$ 200 Hz ± 2% if $>$ 200 Hz
12	Output power factor	$\cos \phi = 1$	
13	Time constant of the output load	Zero	(Resistive load only)
14	Position	Normal position as specified in the instruction manual	
15	Ventilation	According to the instruction manual	

(*Continued*)

TABLE 1 REFERENCE CONDITIONS FOR TEST PURPOSES — *Contd*

SL No.	INFLUENCE QUANTITY OR CHARACTERISTIC	REFERENCE CONDITIONS	TOLERANCE ON REFERENCE VALUES
(1)	(2)	(3)	(4)
16	Magnetic field of external origin	No measurable value	Terrestrial field
17	Other influences, such as vibration, dust, etc	No measurable value	Negligible values

NOTE 1 — The distortion is determined by a factor β in such a way that the waveform is inside an envelope formed by:

$$y1 = A\ (1 + \beta)\ \sin \omega t, \text{ and}$$
$$y2 = A\ (1 - \beta)\ \sin \omega t$$

Distortion values are to be measured with the supply apparatus not connected.

NOTE 2 — For ac supplies (*see* **1.2**), the distortion factor of the input waveform shall be less than 5 percent, as an additional requirement.

NOTE 3 — When the supply apparatus under rated load is connected to the source and determined by measuring the rms value. Special agreement between manufacturer and user may be necessary when the apparatus takes a pulse load from the supply mains due to its regulation process or due to a pulse load connected to it which may result in a pulse shape of the voltage drop.

TABLE 2 RATED OPERATING CONDITIONS FOR APPARATUS OF USAGE GROUP I

(*Clause* 3.4.1.3)

SL No.	INFLUENCE QUANTITY	RATED RANGE OF USE
(1)	(2)	(3)
1)	*Influence quantities where the effect due to their slow change only is to be considered*	
	a) Ambient temperature	+ 5°C to + 40°C
	b) Input frequency	Rated value ± 5 percent
	c) Input waveform distortion	Limit of envelope distortion $\beta \leqslant 0.05$ (*see* Notes 1 and 2)
	d) Input source impedance	To be specified by the manufacturer
	e) Outpower factor	Between the limits as quoted by the manufacturer

(*Continued*)

TABLE 2 RATED OPERATING CONDITIONS FOR APPARATUS OF USAGE GROUP I — *Contd*

SL No.	INFLUENCE QUANTITY	RATED RANGE OF USE
(1)	(2)	(3)
2)	*Influence quantities where the effects both due to slow changes and step changes are to be considered.*	
	a) Input voltage	Rated value ± 10 percent
	b) Output current (supply apparatus with stabilized Voltage)	Between 0 percent and 100 percent *Max* rated values unless other limits are quoted by the manufacturer
	c) Output voltage (supply apparatus with stabilized current)	

NOTE 1 — At any phase position of the harmonics against the fundamental wave and measured with the supply apparatus not connected.

NOTE 2 — For ac supply apparatus (*see* **1.2**), the distortion factor of the input waveform shall be less than 5 percent, as an additional requirement.

3.4.2 *Further Conditions*

3.4.2.1 Protective earth terminals, if any, shall be connected to earth.

3.4.2.2 In the case of dc or single-phase ac mains supply, unless otherwise indicated in the instruction manual, line and neutral leads shall be interchanged.

3.4.2.3 Any optional accessories connected to the apparatus or not.

3.5 Preparation for Tests — Before tests are performed, the following shall apply.

3.5.1 Adjustments, if any, shall have been performed according to the manufacturer's instructions.

3.5.2 Before being turned on, the apparatus shall be in equilibrium with the temperature and humidity of the ambient air.

3.5.3 The apparatus shall then be operated under reference conditions and with rated load for a period equal to the warm-up time as indicated by the manufacturer. In the absence of an indication, this period shall be 1 hour.

3.5.4 After warm-up time, additional adjustments may be performed by means of controls provided for that purpose and according to the manufacturer's instructions.

4. DETERMINATION OF ERRORS

4.1 The error of a stabilized quantity shall be determined as the difference between the true value of the output quantity and the rated or preset value, the latter being represented by the name-plate, potentiometers or rotary switches with scales, and indicating instruments, or the like.

4.2 Measurements of the error shall be performed under steady-state conditions. If several values of a stabilized quantity can be set, the errors are determined at the minimum, the centre and the maximum value of the rated range.

If there is more than one stabilized quantity, the errors are determined at each possible combination of these three values of each quantity.

If more than one maximum rated value of voltage or current is assigned to the apparatus, so that more than one pair of maximum rated values exists, the test shall be performed for each pair separately and according to the directions given above (*see also* **11.2.4**).

4.3 The values of the error shall be evaluated as relative error referred to the true value, or as relative error plus a constant term (for example 0·5 percent ± 50 mV). It shall not exceed the value as stated by the manufacturer.

4.4 Determination of Controlability — Tests may be agreed between the manufacturer and the user.

5. DETERMINATION OF THE OPERATING ERROR

5.1 General — Measurements of the operating error are performed starting at reference conditions as prescribed in Table 1 and at the combinations of any values — within the rated operating conditions — of those influence quantities for which tests have been agreed. When influence quantities are to be varied during these tests, this shall be made as specified below. These procedures apply also to the determination of influence errors and variations (*see* **7**) wherever possible.

5.2 Particular Requirements

5.2.1 *Effects on the Output Voltage (Current) Due to Changes of the Input Voltage* — The apparatus shall be preconditioned according to **3.5**, and the reference conditions include rated load applied to the output.

In the case of several outputs, the total maximum rated load shall be applied to the apparatus and be shared so that the output under test is under its rated load. In case of more than one rated load value, the combination of voltage and current which results in the maximum variation shall be evaluated.

The method for producing the changes of input voltage is not prescribed, but shall be made so that the input values of distortion, ripple and source impedance remain within the tolerances according to Table 1 or 2.

The first reading of the output voltage (current) is made after a time equal to 5 times the rated recovery time following the change of input voltage. After this, the test shall be continued and the output voltage (current) be recorded at suitable intervals for 1 hour.

None of the values observed after increase and decrease of the input voltage shall be outside the limits of operating error nor shall, if specified, any variation exceed the stated limit.

5.2.2 *Effects on the Output Voltage (Current) Due to Changes of the Input Frequency* — One change of the input frequency shall be made in both directions and within 30 to 60 seconds.

Further test procedure shall be as described in **5.2.1**.

5.2.3 *Effects on the Output Voltage (Current) due to Changes of the Output Load Current (Voltage)* — The apparatus shall be pre-conditioned according to **3.5**. In case of more than one rated load value, the combination of voltage and current which results in the largest effect shall be evaluated.

The method for producing the changes of the load current (voltage) according to Table 2 is not prescribed. Further procedure shall be as indicated in **5.2.1**.

5.2.3.1 *Effects of periodic pulse load* — The effects of superposing variations and resonance found under pulse load may be agreed between the user and the manufacturer.

5.2.3.2 *Interaction between outputs* — When measuring the operating error, the variations of the output voltage (current) of one output due to changes of load current at another output of apparatus having more than one output shall be considered.

5.2.4 *Effects on the Output Voltage (Current) due to Changes of Ambient Temperature* — Measurements shall be made over the entire rated range of use and by steps of 10°C or by continuously changing the temperature.

Before the first step, the apparatus shall be operated at a temperature equal to the lower limit of the rated range of use, until thermal equilibrium has been reached. The temperature shall then be increased by 10°C and the apparatus shall then be operated until the new equilibrium has been reached. The values of the output voltage (current) shall be recorded at suitable intervals until equilibrium has been reached.

Further steps shall then be performed successively until the upper limit of the rated range of use has been reached. After this, the temperature shall be decreased in the same way so that a complete cycle is performed.

Continuous changes of temperature is allowed as well, provided that the change is performed slowly enough to keep the apparatus in thermal equilibrium.

None of the changes shall result in values outside the limits of operating error or influence error, or in a variation exceeding the stated value.

Where a temperature coefficient in percent per °C has been stated, it shall be verified that there is compliance with it in the worst part of the temperature characteristic. Differences found between the initial and final value of one cycle shall be considered as drift.

5.2.5 *Effects on the Output Voltage (Current) due to Changes of Input Waveform Distortion* — Tests may be agreed between the user and the manufacturer.

5.2.6 *Effects on the Output Voltage (Current) due to Changes of Input Source Impedance* — Tests may be agreed between the user and the manufacturer.

5.2.7 *Effects on the Output Voltage (Current) due to Changes of the Output Power Factor* — Changes of the output power factor shall be made by connecting or disconnecting appropriate capacitors or inductive coils, as applicable, in such a way that the active output power remains unchanged.

Further procedure shall be as described in **5.2.2**.

5.2.8 *Effects on the Output Frequency* — Compliance tests on variations of the output frequency shall, in general, be made with supply apparatus which incorporate frequency stabilizing or transforming devices.

Tests will, in general, be performed to determine only the changes listed in **5.2.1** to **5.2.4** and according to the specifications contained in these clauses.

6. DETERMINATION OF THE INTRINSIC ERROR

6.1 Measurements are performed under reference conditions as specified in Table 1 and all influence quantities listed there, except the stabilized quantity concerned, shall be kept within the specified tolerances.

7. DETERMINATION OF INFLUENCE ERRORS AND VARIATIONS

7.1 General

7.1.1 Starting with the apparatus under reference conditions as specified in Table 1, the influence errors or variations are determined for each influence quantity (or influencing characteristic) separately.

Influence errors and variations may be determined under steady-state conditions.

For transient conditions, only variations may be applied.

7.1.2 Influence errors and variations shall be determined by varying each influence quantity in turn within its rated range or use. The test shall be performed within the range as specified in Table 2, unless the manufacturer has quoted a range of use which exceeds the values of Table 2. The procedures are described in **5.2** to **5.2.8**.

7.2 The degree of variation is assessed as follows:

a) When a reference value is indicated, the influence quantity may be varied between that value and any value within the limits of the rated range of use, as given in Table 2;

b) When a reference range is indicated without reference to a rated range of use, the apparatus is exempted from tests regarding variations; and

c) When limits of the reference range and a rated range of use are indicated, the influence quantity is varied between each of the limits of the reference range and any value in that part of the rated range of use adjacent to the chosen limit of the reference range.

7.3 Transient Variations

7.3.1 *Transient Variations of the Output Voltage (Current) Due to Changes of the Input Voltage* — Changes of the input voltage shall be performed as sudden and sustained steps.

For apparatus supplied with dc, a sudden voltage change of + 10 percent and a sudden voltage change of − 10 percent, starting from the rated voltage, are applied. At least ten changes each in both directions at random moments shall be performed with supply apparatus with ac input.

The rise time of the changes shall, in general, be of the order of the recovery time of the apparatus. Where recovery time is not specified, the rise time of the changes shall be 1 second.

NOTE — Although correct results will be obtained only when the rise time is of the order of the recovery time, this method of test might need modification for apparatus designed for large input power or high input frequency. In this case the manufacturer shall indicate the recommended method for test.

The output voltage (current) shall be recorded by an oscilloscope starting prior to changing the input voltage, and continuing until steady-state conditions have been reached. The oscilloscope shall have sufficient bandwidth.

None of the variations observed during and after the changes shall exceed the stated value.

7.3.2 *Transient Variations of the Output Voltage (Current) Due to Changes of the Output Load Current (Voltage)* — Changes of the output load current (voltage) shall be made by connecting and disconnecting resistors, thus changing the output current (voltage) in one step between the limits stated in Table 2.

Further procedure shall be as indicated in **7.3.1**.

NOTE — The decay time produced by the switching device shall be short compared with the recovery time of the apparatus under test. Where the variation measured, when disconnecting the load, depends upon the decay time the indications of the manufacturer concerning the device to be used shall be observed.

7.3.3 The records of these tests may also be used to determine overshoot and recovery time, as indicated in **8.2**, and, with supply apparatus incorporating frequency stabilization, to determine transient variations of output frequency.

7.4 Tests for determining variations caused by influence quantities other than those indicated above may be performed upon agreement.

7.5 Tests for verifying performance qualities under limit conditions of operation, storage and transport may be requested upon agreement.

8. TESTS ON FURTHER ELECTRICAL QUANTITIES

8.1 Tests as described in this clause shall be performed under the following conditions and with maximum rated load applied to the apparatus, unless otherwise specified:

a) Temperature not outside the range of 15°C to 35°C;

b) Relative humidity not outside the range of 20 percent to 80 percent; and

c) Air pressure not outside the range of 70·0 kPa to 106·0 kPa (corresponding to altitudes up to 2 200 m).

The apparatus shall be in equilibrium with the temperature and humidity of the ambient air, shall be preconditioned for a period equal to the warm-up time, unless otherwise specified, and shall be operated at rated input voltage and frequency.

8.2 Transient Performance

8.2.1 Transient deviations due to sudden changes of input voltage and output load current shall be determined from the records obtained during the test as described in **7.3.1** and **7.3.2**.

From the records the following shall be determined:

a) The maximum overshoot amplitude,
b) The recovery time, and
c) The variations of output frequency.

None of the values abtained from the particular directions of change or from the particular steps shall exceed the values as indicated by the manufacturer.

8.2.2 In order to measure the recovery time, the centre and the width of the operating error band (*see* B_N in Fig. 3) should be determined first. The central value of the band will be given by the rated value of the output voltage (current). The width of the band will be given by the stated operating error limits.

8.2.3 Any excess relative to the preset value during the warm-up time shall not exceed the values stated by the manufacturer, which may be expressed as an absolute value, and may conveniently be determined during the warm-up time as specified in **3.5.3**.

8.2.4 Tests on build-up and decay time — between switching on (off) the apparatus and the appearance (disappearance) of the output quantity may be agreed between the user and the manufacturer.

8.2.5 The turn-on/turn-off overshoots shall be determined with the apparatus under reference conditions and with the smallest permissible load current drawn from the apparatus. With voltage stabilized apparatus, the output shall be so set as to obtain the minimum possible current.

The input voltage is then disconnected for a period between 0·05 s and 180 s, whichever results in the maximum overshoot, and the output voltage is observed including the instant of disconnection until steady-state in the turn-on condition has been reached.

The overshoot shall not exceed the values stated by the manufacturer, which may have been expressed as an absolute value or as the ratio to the steady-state value, as also the stated time and numbers of overshoot, if so indicated.

8.3 Phase Shift — The highest and the lowest values of phase shift of the output voltage with respect to the input voltage of ac supply apparatus shall be determined under reference conditions and for all values of input voltage and load current within their rated ranges of use.

A positive value shall be assigned if the output voltage leads the input voltage and a negative if *vice versa.*

Both the highest and the lowest values obtained during this test shall be within the limits as stated by the manufacturer.

8.4 Waveform Distortion — The waveform distortion of the output voltage of an ac supply apparatus shall be determined at any value of input voltage, input frequency and output load current within their rated ranges of use, and in that combination which results in the maximum distortion.

Measurements may be carried out:

a) with undistorted (sine-wave) input voltage, and

b) by measuring the individual harmonics successively and by filtering the harmonic concerned from the input voltage. This method may be used provided that the total harmonic content of the input voltage does not exceed 5 percent.

The waveform distortion shall not exceed the values as indicated by the manufacturer.

8.5 PARD (Periodic and Random Deviations) — The PARD of the output voltage of a dc supply apparatus shall be determined under the conditions as indicated in **8.4** (a).

Values shall preferably be recorded so that the effective value and the peak-to-peak value can be determined.

The values obtained from the test shall be within the limits as stated by the manufacturer.

8.6 Output Impedance

8.6.1 *Steady-State Load* — The determination of output impedance of ac supply apparatus or of output resistance of dc apparatus, under constant load, is obtained from the records of the tests as described in **5.2.3**. It will be represented by the value of the ratio of the changes of output voltage and current.

8.6.2 *DC Output with Load Containing Periodic Components* — In order to determine the output impedance, an ac voltage or current is fed into the output of the supply apparatus. Examples for measuring set-up are shown by Fig. 5A and 5B. The frequency of the externally applied ac voltage shall be varied within the range for which the statements are valid.

The working point shall be adjusted to 90 percent rated load current. In each case, the fed-in voltage (or current) should not cause the output value to exceed its rated range and should be as small as possible to allow for reliable measurement.

NOTE — At high frequencies, the test is performed according to Fig. 5B.

8.6.3 *AC Output With Load Conductance Changing Periodically* — Tests may be agreed between the user and the manufacturer.

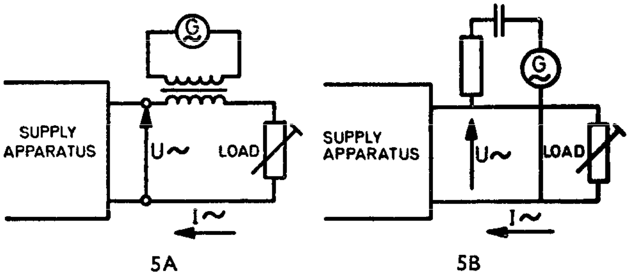

FIG. 5 SET-UP FOR MEASURING OUTPUT IMPEDANCE

8.6.4 *Equivalent Output Impedance* — Tests may be agreed between the user and the manufacturer.

8.6.5 The values of output impedance or resistance, determined in the frequency range, as applicable, shall not exceed the limits as stated by the manufacturer.

8.7 Transfer Capacitance — The transfer capacitance of a supply apparatus is determined with the rated load applied to the output. The apparatus is supplied by a circuit, one pole of which is earthed. The test is applicable to apparatus only having a floating output.

Measurements are performed by connecting an appropriate capacitor between one output terminal and earth potential (for example the enclosure of the apparatus) and the mains hum is measured across the external capacitor. The test is repeated for:

a) both positions of the mains plug, and
b) each output terminal

The apparent internal capacitance amounts to:

$$C_1 = \frac{V_H . C_E}{V_M}$$

where

C_E = capacitance of the external capacitor,
V_H = hum voltage, and
V_M = mains voltage.

In case of doubt whether a built-in capacitor might influence the result, measurements shall be made twice with two different external capacitors C_{E1} and C_{E2} with a ratio of approximately $C_{E1} = 2C_{E2}$ and both having a larger capacitance than the built-in capacitor. The apparent internal capacitance amounts then to:

$$C_1 = \frac{C_{E1} - C_{E2}}{\frac{V_M}{V_{H1}} - \frac{V_M}{V_{H2}}}$$

where

V_{H1} = hum voltage obtained with C_{E1}, and
V_{H2} = hum voltage obtained with C_{E2}.

NOTE — Similar measurements may be expedient with supply apparatus having a guarded output as far as the potential of the guard terminal against other terminals is concerned. Such potential might result in parasitic current through subsequent devices connected to the power supply.

8.8 Capacitance of the Output Circuit to Frame — Unless the value is discernible, a test shall be made to determine the capacitance. The apparatus shall be inoperative and shall have no connections whatsoever.

The capacitance from each output terminal to earth potential (for example, the enclosure of the apparatus) is measured by an appropriate device, such as a capacitance measuring bridge.

8.9 Insulation Resistance — The insulation resistance shall be measured with the apparatus not connected to its supply source. A dc voltage of 100 V unless otherwise specified is applied to it and the measurement is carried out 1 minute after application:

a) for output circuit(s) internally connected to the input between:
    i) the frame, and
    ii) all output terminals short-circuited and connected together; and

b) for output circuit(s) insulated from the input, between:
   i) the frame connected to one input terminal, and
   ii) all output terminals short-circuited and connected together.

NOTE 1 — The insulation between different output circuits may be considered.

NOTE 2 — The measurement refers to the functional performance of the apparatus. It may not be adequate for safety purpose.

8.10 Limit Conditions of Operation of the Output

8.10.1 *Maximum Floating Voltage* — Tests may be agreed between the user and the manufacturer.

8.10.2 *Maximum AC Components in the Load Current of DC Supply Apparatus* — Tests may be agreed between the user and the manufacturer.

8.11 Output Capacitance — Measurements shall be performed similarly to that described in **8.8**.

8.12 Stability Error (Drift) — Upon the choice of the manufacturer, the drift may either be included in the operating error or may be stated as a separate item.

8.12.1 When the drift has been included in the operating error, the apparatus is operated at any values within the rated conditions of operation as indicated in **5.1** and for a period equal to that for which the statement on drift is valid. The period of validity shall be chosen according to the relevant table of IS : 9176-1979*.

At any time during the test the operating error shall not exceed its limits.

8.12.2 When the drift has been stated separately, the following applies:

The drift shall be determined under reference conditions, at rated load applied to the output and with the highest rated value of output voltage (current) set. These conditions shall be kept constant and the output voltage (current) shall be recorded for 7 hours immediately following the warm-up time. From the records, the following shall be determined (*see* Fig. 6 and Table 3):

a) the short-term drift is determined within the 7-hour period for that interval of 15 minimum during which the maximum excursion occurs; and
b) the long-term drift is determined during the 7-hour period as the peak-to-peak difference.

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The maximum values thus obtained shall not exceed the values as stated by the manufacturer.

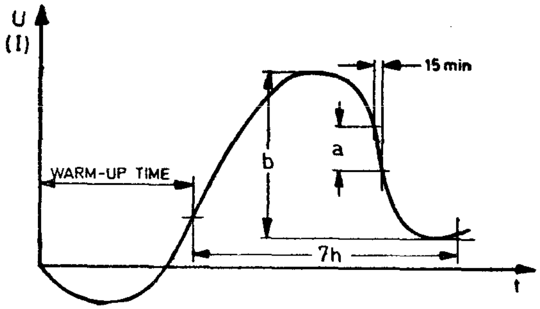


Fig. 6 Determination of the Drift

9. TESTS ON THE PERFORMANCE AND THE PROTECTION OF THE APPARATUS

9.1 Cross-Over Regulation — The performance of cross-over regulation will in general be evaluated from the results of the tests carried out on the variation of output voltage and output current due to changes of the output load, as described in **5.2.3**.

Tests for determining the performance within the cross-over area may be agreed upon between the manufacturer and the user.

9.2 Current Limiting, Other than by Means of Cross-Over Regulation

9.2.1 Apparatus providing current limiting by decreasing the voltage at increasing current shall be tested as follows:

a) When a current equal to 110 percent rated current or preset current value is drawn from the output, the output voltage shall be less than at 100 percent current; and

b) When a short-circuit or the minimum admissible load resistance is applied to the output, the output current shall be less than 150 percent rated current or preset current value.

9.2.2 Apparatus providing current limiting by fold-back characteristics (*see* Fig. 4) shall be tested as follows:

a) When a current equal to 110 percent rated current or preset current value is drawn from the output, the output voltage shall be less than at 100 percent current;

b) When a resistor, having any value between infinity and zero, is applied to the output, the output current shall be less than 125 percent rated current or preset current value; and

c) When a short-circuit is applied to the output, the output current shall be less than 100 percent rated current or preset current value.

9.2.3 *Short-Circuit Protection* — This test applies to apparatus according to **2.14.2** only. The apparatus shall be operated as indicated under **8** and the output(s) shall be short-circuited:

a) for apparatus with short-circuit protection, for a period of 24 hours; and

b) for apparatus with limited short-circuit protection, for a period as quoted.

After this test, the apparatus shall comply with all requirements and shall show no damage.

10. POWER (MAINS) SUPPLY INPUT

10.1 Power supply requirements of a supply apparatus shall be determined at reference conditions and with maximum rated load applied to the output(s).

10.2 Current consumption of an ac supply apparatus is determined at that rated output power factor which results in the maximum current consumption. The current consumption shall not differ by more than 10 percent from the stated value.

10.3 Inrush Current — The test set-up given in Fig. 7 may be used with a 240 V ± 10 percent supply system.

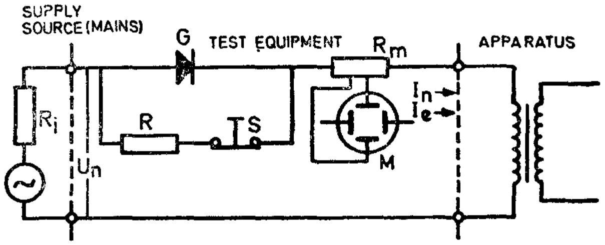
NOTE — It is given as an example only and precautions or modifications may be necessary in some cases.

Test Procedure — The apparatus is connected to mains supply *via* the measuring set-up. The switch *S* is closed and the apparatus is operated.

The switch *S* will then be opened for a short time. After the second period the inrush current reaches its maximum, the peak value of which is noted by the oscilliscope.

In order to avoid overheating of the transformer of the apparatus, it is necessary that the test duration does not exceed about 1 second.

The test shall be repeated at least three times and the maximum inrush current noted.



G = silicon rectifier
inverse voltage $\geqslant$ 600 V
rated current $\geqslant 5 \times I_e$

R = wire-wound resistor
resistance $R \leqslant \frac{1}{I_n}$ (approx 0·1 Ω)
load P $\geqslant I_n{}^2 R$ (approx 6 W)

R_M = shunt-resistor
The resistance shall be chosen so that the voltage drop caused by I_e can be observed by M.

S = switch or key
rated voltage $\geqslant$ 250 V
rated current $\geqslant I_n$

M = calibrated measuring oscilloscope

Fig. 7 Set-Up for Measuring Inrush Current for Use with a Supply System of Approximately 240 V ± 10 Percent

The source resistance of the supply R_i will influence the test result. It shall not exceed:

$$R_i \leqslant 0{\cdot}005 \frac{U_n}{I_n}$$

10.4 Distortion Factor of the Input Current — This test is carried out on apparatus fed by ac supply voltage and an input supply having a source impedance and waveform complying with the values of Table 1 is used, but the distortion factor of the supply voltage should be less than the distortion factor to be tested.

The apparatus is connected to that input supply and operated at rated load. The distortion factor of the input current shall not exceed the value stated by the manufacturer.

10.5 Ripple of the Input Current — This test is carried out on apparatus fed by dc supply voltage and will be performed similarly to the test described in **10.4**. It is suggested that an input supply without any ripple (for example an appropriate storage battery) be used.

11. SPECIFIC CHARACTERISTICS OF SUPPLY APPARATUS

11.1 General Requirements — Characteristics of supply apparatus as specified in **1** shall be stated as applicable and be expressed by using the terms as given thereafter, and by referring to the definitions as stated in **2**. This applies especially to statements given by manufacturers of supply apparatus, such as those contained in data sheets and catalogues.

11.1.1 Properties shall be stated according to the directions given in **4** to **10**. Properties for which statements are not made are deemed not to be available. Quantities for which statements are not made are deemed to be of any value.

11.1.2 Limits of errors shall be stated according to the requirements given in **3.2.1**. Values without tolerances, that is, without limits of error, are informative data and subject to simple checking only.

11.1.3 It is desirable that quantities to which approximate values are assigned should be clearly identified.

11.1.4 The properties for which statements shall be provided are given in Table 3.

12. MARKING

12.1 Details of marking of the apparatus shall, when necessary, be agreed between the user and the manufacturer. As an example, apparatus might need special marking when operation at zero load is dangerous.

TABLE 3 PROPERTIES FOR WHICH STATEMENTS ARE PROVIDED

(*Clause* 11.1.4)

SL No. (1)	TERM (2)	CLAUSE REFERENCE (3)	UNIT (4)	REMARKS (5)
1)	*General Terms*	11.2		
	a) Mode of stabilization	11.2.1		State the operating mode, also whether peak-clipping or resonant circuits or the like are used
	b) Stabilization elements:	11.2.2		
	i) Output control device	11.2.2.1		Describe the manual and/or visible controls, such as potentiometers, rotarv switches and their scales, or indicating instruments
	ii) Reference source	11.2.2.2		For example Zener diode or standard cell and whether or not in a controlled oven
	iii) Comparator	11.2.2.3		For example with saturated diode, baretter, thermistor
	iv) Error amplifier	11.2.2.4		For example with values, semiconductors, or magnetic
	v) Final control element	11.2.2.5		For example values, semiconductors, regulating transformer, saturable reactor, also whether working continuously or in switching mode
	c) Stabilized quantity	11.2.3		State whether dc and/or ac voltage and/or current stability and, for ac only state accepting to 2.3.2.3
	d) Rated values:	11.2.4		State ranges or maximum values as applicable
	i) Output voltage	—	V	A supply apparatus permitting an output up to 10A at 2 V and up to 3A at 30V shall be quoted as: 0......2 V/10 A; 0......30 V/3 A. A statement 0......30 V/10 A is prohibited in this case
	ii) Output current	—	A	
	iii) Maximum load also, if applicable	—	V, A, W V, AΩ	
	iv) Minimum load	—	V, A	If different from zero
	v) Power factor	—		Rated value or range

(*Continued*)

TABLE 3 PROPERTIES FOR WHICH STATEMENTS ARE COVERED — *Contd*

SL No.	TERM	CLAUSE REFERENCE	UNIT	REMARKS
(1)	(2)	(3)	(4)	(5)
2)	*Operating and Test Conditions*	11.3		
	a) Reference conditions	11.3.1		State taking into account Table 1 and IS : 9176-1979*
	b) Rated operating conditions	11.3.2		State taking into account Table 1 and IS : 9176-1979*
	c) Limit conditions of operation	11.3.3		State as applicable. Absence of indication denotes that limit conditions are equal to the rated range of use
	d) Limit conditions of storage and transport	11.3.4		—
3)	*Error limits general*	11.4		
	a) Stability quantity	11.4.1		If more than one, state each of them and their error limits
	b) Control behaviour	11.4.2	As applicable	Resolution or sensitivity
4)	*Operating error*	11.5	% or % ±mV	Drift included
5)	*Intrinsic error*	11.6	% or % ±mV	If differing from operating error
6)	*Influence errors and variations*	11.7		Check always whether separate statements are necessary and consider that all particular error components must be included in the operating error (*see* **7**)
	a) Effects on the output voltage (current) due to changes of:	11.7.1		Steady-state effects for transients, *see* **11.8.1**. Any statement shall be valid for changes throughout the rated range of the influence quantity concerned
	i) Input voltage	11.7.1.1	%	—
	ii) Input frequency	11.7.1.2	%	—
	iii) Output load current	11.7.1.3	%	—

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*Method for specifying functional performance of electronic measuring equipment.

(*Continued*)

TABLE 3 PROPERTIES FOR WHICH STATEMENTS ARE COVERED — *Contd*

SL No.	TERM	CLAUSE REFERENCE	UNIT	REMARKS
(1)	(2)	(3)	(4)	(5)
	iv) Ambient temperature	11.7.1.4	%/10°C	Or %/°C if valid throughout the whole rated temperature range of use
	v) Other influence quantities (under consideration)	11.7.1.5	—	—
	b) Effects on the output frequency	11.7.2	As applicable	Frequency stabilized and/or converting supplies only
7)	*Other electrical quantities*	11.8		
	a) Transient variations	11.8.1		
	i) Transient variations of the output voltage (current) due to:	11.8.1.1		As steps of ± 10% rated voltage
	— Changes of supply voltage			
	— Maximum overshoot amplitude		%	
	— Recovery time		s	
	— Changes of load			As steps of 100% rated load, unless otherwise indicated
	1) maximum overshoot amplitude			
	2) recovery time			
	ii) Transient variations of output frequency	11.8.1.2	As applicable	Frequency stabilized and/or converting apparatus only
	iii) Excess during warm-up time	11.8.1.3	%	
	iv) Build-up/decay time	11.8.1.4	(Under consideration)	
	v) Turn-on overshoot	11.8.1.5	%	Also in V, A and (additionally), s

(Continued)

TABLE 3 PROPERTIES FOR WHICH STATEMENTS ARE COVERED — *Contd*

Sl No.	Term	Clause Reference	Unit	Remarks
(1)	(2)	(3)	(4)	(5)
	vi) Turn-off overshoot	11.8.1.5	%	Also in V, A and (additionally), s
	b) Phase shift:			AC supplies only
	i) maximum value	11.8.2	degrees	Statement of tolerance is mandatory
	ii) minimum value	—	degrees	Statement of tolerances is mandatory
	c) Waveform distortion:	11.8.3	%	AC supplies only
	i) Harmonic content			For each harmonic or spectrum
	ii) Distortion factor			Mandatory
	iii) Distortion factor ratio		%	Preferable with waveform stabilized supplies
	d) PARD	11.8.4		DC supplies only
	i) Amount, rms value		V	
	ii) Amount, peak-to-peak		V	
	e) Output impedance	11.8.5		
	i) Steady-state load	11.8.5.1		
	— output impedance		Ω	AC supplies
	— output resistance		Ω	DC supplies
	ii) Load containing periodic components	11.8.5.2	Ω	DC supplies } State also test conditions or diagrams
	iii) Periodically changing load conductance	11.8.5.3		AC supplies
	iv) Equivalent output impedance	11.8.5.4		State test conditions and shape of steps or pulses
	f) Transfer capacitance	11.8.6	pF	
	g) Capacitance output/frame	11.8.7	pF	
	h) Insulation resistance	11.8.8	MΩ	

(*Continued*)

TABLE 3 PROPERTIES FOR WHICH STATEMENTS ARE COVERED — *Contd*

Sl No.	Term	Clause Reference	Unit	Remarks
(1)	(2)	(3)	(4)	(5)
	k) Output terminal connection	11.8.9		Input and output connected/ insulated. Floating output
	i) Maximum floating voltage	11.8.9.1	V	Note — Floating output will, for safety of the user, be subjected to a high voltage test according to IS :..... .....*
	ii) Maximum permissible ac component in the load current	11.8.9.2	A	DC supplies
	m) Output capacitance	11.8.10	µF	
	n) Drift	11.8.11		
	i) If contained in the operating error	11.8.11.1	Hours, days, months	Interval for which the operating error is valid
	ii) If stated separately:	11.8.11.2		
	1) short-term drift	% V, A	% V, A	Maximum 15 min drift
	2) long-term drift	% V, A	% V, A	Peak-to-peak value of 7 hours drift
	p) Warm-up time	11.8.12	minutes	
8.	*Performance and protection*	11.9		
	a) Cross-over regulation:	11.9.1		State whether provided
	i) cross-over voltage		V	Rated values or adjustable
	ii) current limit		A	Rated values or adjustable ranges
	b) Current limiting:	11.9.2		State whether provided. State mode of limiting or adjustable range
	i) limit value	—	A	
	c) Short-circuit protection:	11.9.3		State whether provided. Time limited
	i) time limit		minutes, hours	Voltage automatically restored. Signal

*Safety requirements for electronic measuring apparatus (*under preparation*).

(*Continued*)

TABLE 3 PROPERTIES FOR WHICH STATEMENTS ARE COVERED — *Contd*

SL No. (1)	TERM (2)	CLAUSE REFERENCE (3)	UNIT (4)	REMARKS (5)
	d) Overload protection	11.9.4		
	i) Current breaking device	11.9.4.1		State whether provided. Describe kind of device and reset
	ii) Electronic blocking device	11.9.4.2		State whether provided. Describe kind of device and reset
	e) Over-voltage/under-voltage protection	11.9.5		State whether provided. Operating threshold value(s) and time. Signal? Action on...? Reset
	f) Reverse voltage protection	11.9.6		State whether provided. Operating threshold value(s) and time. Signal? Action...? Reset
	i) maximum allowed reversed voltage		V	
	ii) maximum allowed forward voltage		V	For...milliseconds
	g) Reverse current protection	11.9.7		State whether provided
	h) Over-temperature protection	11.9.8		State whether provided
9)	*Supply requirements*	11.10		
	a) Rated values:	11.10.1		Or rated ranges
	i) valtage		V	
	ii) frequency		Hz	
	b) Current consumption	11.10.2	A	At rated output load
	c) Inrush current	11.10.3	A	
	d) Distortion of the input current	11.10.4	%	For ac input
	e) Ripple of the input current	11.10.5	%	For dc input
	f) Input power factor	11.10.6		In case of sinusoidial input voltage and current, state cosϕ only
	g) Input displacement factor	11.10.7		
	h) Efficiency	11.10.8		

(*Continued*)

TABLE 3 PROPERTIES FOR WHICH STATEMENTS ARE COVERED — *Contd*

SL No.	TERM	CLAUSE REFERENCE	UNIT	REMARKS
(1)	(2)	(3)	(4)	(5)
10)	*Auxiliary facilities*			
	a) Remote control facility	11.11.1		State whether provided. Acting on
	i) Allowed distance		m	
	ii) Remote current breaking facility	11.11.1.1		State whether provided. Required operating signal
	b) Remote sensing facility	11.11.2		State whether provided
	i) Allowed line resistance		Ω	
	c) Tracking facility	11.11.3		State whether provided
	d) Parallel operation facility	11.11.4		State whether provided. Additional indications as applicable
	e) Series operation facility	11.11.5		State whether provided. Additional indications as applicable
11)	*Accessories*	11.12		
12)	*Miscellaneous*			
	a) Weight	11.13.1	kg	Normal accessories included
	b) Length	11.13.2	mm	Over projections
	i) Width		mm	Over projections
	ii) Height		mm	Over projections
	c) Value/transistor complement	11.13.3		State also whether regular or selected types
	d) Cooling:	11.13.4		Convention/forced ventilation
	i) Air consumption		m^3/h	At a pressure of to...
	e) Enclosure/Protection	11.13.5	IP number	Indoor/outdoor use? According to IS : 2147-1962*
	f) R. F. radiation	11.13.6		Determined according to IS : 4546-1968†
	i) Conducted interference			
	— symmetrical		μV, mV	
	— asymmetrical		μV, mV	
	ii) Radiated interference		μV, mV	State method of measurement
	g) Safety class	11.13.7		According to IS : ..... ‡
	i) Connection of protective earth			For Safety Class I apparatus only

*Degrees of protection of enclosures for low-voltage switchgear and controlgear.

†Methods of measurement of radiation from television receivers.

‡Safety requirements for electronic measuring apparatus (*under preparation*).